ACCURACY OF VARIOUS IOL POWER CALCULATION FORMULAS IN INDIAN EYES USING IOL MASTER

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CERTIFICATE

Certified that this dissertation entitled **''Accuracy of various IOL power calculation formulas in Indian eyes using IOL master''** submitted to the Tamil Nadu DR.M.G.R Medical university, March 2013 is the bonafide work done by **Dr.Janani**, under our supervision and guidance in the cataract services of Aravind Eye Hospital and post graduate institute of Ophthalmology, Madurai, during her residency period from May 2010 to April 2013

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INTRODUCTION

Cataract is the leading cause of blindness in the world . Cataract surgery is now becoming more like a refractive surgery**.**

In cataract surgery, for achieving optimum outcome, accurate biometric method and IOL power formula is necessary. Determining the power of the intraocular lens to be implanted is an important factor in the postoperative refractive status and visual acuity.[1-3] Phacoemulsification with foldable IOL implantation is becoming popular among the affluent society of developing countries, although in developed countries it is the standard procedure. Its advantages being greater wound stability and hence earlier rehabilitation and less astigmatism in the changing social economic scenario.

IOL master is a non contact optical device that works under the principle of partial coherence Interferometry and it measures various parameters with highest precision in IOL power calculation and good outcome in cataract surgery.

IOL power formulas

The first IOL power calculation formula was published by Fydorov and kolonko in 1967. In 1978,Lloyd and Gills,Rezlaff,Sanders and Kraff developed a regression formula based on the analysis of their previous IOL cases.In

1981,Binkhorst presented his modified formula which had better predictability than the first generation. Third-generation formulas (Holladay 1, SRK/T, and Hoffer Q) improved the predictor of effective lens position . Fourth-generation formulas such as the Holladay 2 is a refraction formula which requires corneal power,preoperative refractive error,and desires post operative refraction.

Of the available diagnostic instruments ,the IOLMaster measures AL with the highest precision. The IOL Master provides all biometric parameters and various formulas for IOL power calculation.

The purpose of this study was to evaluate the predictability of IOL power calculations using five IOL power calculation formulas (SRK II,Haigis, SRK T,Hoffer Q,holladay I) using the IOL master

REVIEW OF LITERATURE

1. Emmetropization at cataract surgery, looking for the best IOL power calculation formula according to the eye length.

Arch Soc Esp Oftalmol. 2003 Sep;78(9):477–80

R Donoso, J J Mura, M Lopez, A Papic et al determined the predictability of different intraocular lens power calculation formulas(SRK-II,Binkhorst-II,HofferQ,SRK T,Holladay) in 212 cases who underwent phacoemulsification with IOL implantation. the predicted postoperative refractive error for each formula was determined according to the axial length and it was compared to the result. There was no statistical difference between the formulas for the AL group between 22 and 28 mm . the error between the AL group of 28 mm and the group between was not statistically significant for SRK-T[5].

2. Intraocular lens power calculation using the IOLMaster and various formulas in eyes with long axial length

Journal of cataract and refractive surgery. 2008 Feb;34(2):262–7.

Jia kangwang,MD, et al evaluated the accuracy of intraocular lens power calculations using theIOL Master and different IOL power calculation formulas in long eyes. They have included 68 eyes with an AL longer than 25.0 mm who underwent phacoemulsification with intraocular lens implantation.For group 1 patients they have measured preoperative AL and keratometry using IOL Master and with applanation ultrasound and automatic keratometry for group 2 patients.The predicted postoperative error was calculated by various formulas SRK II,SRK T and Holloday 1(group 1 and 2) and Haigis(group),the mean absolute error was analysed. The mean axial length was significantly longer in group 1 than in group 2.

They have concluded that the intraocular lens power calculated using the Haigis formula predicted the best refractive outcome in long eyes.[6]

3. **Accuracy of intraocular lens power prediction using the Hoffer Q, Holladay 1, Holladay 2, and SRK/T formulas**.

J Cataract Refract Surg. 2006 Dec;32(12):2050–3.

Julio Narvaez, MD, GrenithZimmerman, Daniel H.chang,MD et al compared the accuracy of intraocular lens power calculations using 4 IOL power calculation formulas HofferQ,Holladay1,Holladay 2, and SRK-T.

It was a retrospective study in 643 eyes using immersion ultrasound biometry.manual keratometry, and postoperative manifest refraction were obtained in 643 eyes of consecutive patients who had uneventfull cataract surgery with IOL implantation by same surgeon. The predicted post operative results were compared to the postoperative refraction for each formula. And they have found out that no statistical difference between the formulas as measured by mean absolute error.[7]

4. Intraocular lens power calculation formulas in Chinese eyes with high axial myopia.

J Cataract Refract Surg. 2003 Jul;29(7):1358–64.

Collete S.L.Tsang et al studied 125 patients who had axial length longer than 25.0mm . the predicted postoperative refractive error was calculated by 4 IOL power calculation formulas,Hoffer Q,SRK II,SRK-T,and Holladay1. The absolute error was calculated by comparing the difference between the actual and predicted postoperative refractive errors and the accuracy of each formula were analysed. Of the four formulas, the Hoffer Q formula predicted the best refractive outcome in long eyes.[8]

5.Accuracy of IOL calculation in cataract surgery.

Acta Ophthalmol Scand. 1997 Apr;75(2):162–5.

R Brandser,E Haaskjold,LDrolsum et al calculated the accuracy of IOL calculation in 515 cataract extractions with posterior chamber IOL s using SRK II formula.

Preoperatively the patients were divided into different groups according to their refractive status and mean postoperative refraction was calculated in each group. The mean postoperative refraction increased almost linearly with increasing myopic status they concluded that the SRK II formula is inaccurate for myopic eyes.[9]

6.Accuracy of Intraocular Lens Power Calculation in Short Eyes using IOL master

Korean J Ophthalmol 2011 Jun;25(3):151–5.

Young Rae , et al evaluated the accuracy of intraocular lens power calculations for four different IOL power calculation formulas (SRK II,Haigis, Hoffer Q, and SRK/T) using IOL master in eyes with a short axial length (<22 mm)in 25 eyes,who underwent phacoemulsification with intraocular lens implantation.It was a retrospective comparative analysis , Preoperative Axial length and keratometric index measurement were calculated by the IOLMaster, and the predicted postoperative refractive error was Obtained using SRK II, Haigis, Hoffer Q, and SRK/T formulas.Two months after cataract surgery, postoperative refractive error was calculated using automatic keratometry. results were compared with the predicted postoperative power.

The mean absolute error was smallest with the Haigis formula, followed by those of SRK/T , SRK II, and Hoffer Q in 25 eyes with an AL shorter than 22.0 mm.They have inferred that the Haigis formula predicted the best refractive outcome in short eyes.[10]

7.**Intraocular lens power calculation in short eyes.**

Eye(lond).2008 jul;22(7):935-8.

Gavin EA, et al compared the accuracy of the Hoffer Q and SRK-T formulae in eyes below 22 mm in axial length, in 41 patients, without a customised ACD constant. Biometry was performed using IOL master and IOL power was calculated using both SRK-T and Hoffer Q formulae . Refractive outcome was measured and the accuracy of the two formulae compared..Hoffer Q was found to be more accurate than the SRK-T formula in this series of eyes <22 mm axial length when customised ACD constants are not used[29]

8. **comparison of the SRK T and other theoretical and regression formulas.**

J Cataract Refract Surg.1990 may;16(3);341-6

Sanders DR,retzlaff JA et al[28] compared the predictive accuracy of the SRK/T formula to the SRK II, Binkhorst II, Hoffer, and Holladay formulas in seven series of cases .In short eyes (less than 22 mm), all formulas performed well, with the SRK/T, SRK II, and Holladay formulas performing marginally better. In moderately long eyes (greater than 24.5 mm, less than or equal to 27 mm) the SRK/T and Holladay were again marginally better. In the very long eyes (greater than 27 mm and less than or equal to 28.4 mm), all formulas performed well.

IOL POWER CALCULATION FORMULAS

The IOL power prediction formulae:

To achieve greater levels of accuracy in predicting IOL power that would result in desired post operative spherical outcomes, four generations of IOL formulae were enumerated.[13]

- *First Generation* - SRK- 1 and the Binkhorst formula.
- *Second Generation* – SRK-2
- *Third Generation* – SRK T, Hollday. Hoffer-Q
- *Fourth Generation* – Hollday 2, HAIGIS.

These formulae could either be ‘Theoretical formulae’ based on mathematical principles revolving around the ‘schematic eye’ or they could be ‘regression formulae’ which are arrived at, by looking at post operative outcomes and working backwards in what is known as the regression analysis.

The Third and fourth generation formulae incorporate both theoretical and regression .

THE SRK FORMULA

This Was described by Donald Sanders, John Retzlaff and Kraff in the mid 1980's. The formula attempted to predict the IOL power based on the axial length and the average central corneal power.[14]

- IOL power = A – 2.5 L – 0.9 K.
- L = axial length (mms)
- K = average central corneal power (Diopters.)

The first generation SRK formula worked well for axial length ranges between 22.0m – 24.5mm

To increase its predictability the SRK 2 formula was introduced in which additions were made to the A constant in axial lengths less than 22mms and 0.5 was subtracted from the A constant for axial lengths over 24.5mms.

SRK 2

- Axial length 21-22mm, add 1 to A
- 20-21 add 2
- < 20 add 3

Long eyes:

Over 24.5mm subtract 0.5mm from the A. With this modification the SRK 2 formula was reliable in predicting IOL powers between the axial length range of 20.0mm- 26.0mm but still unreliable in shorter and longer eye balls.

SRK T FORMULA

The SRK T formula is a third generation formula, described in 1990 by John Retzlaff and Donald Sanders. It combines the benefits of both the theoretical and regression formulae. The SRK T formula uses theoretical elements like predicted post operative anterior chamber depth, refractive indices of the cornea and retinal thickness.[15]

This formula works well in eyes of normal length and moderately long and very long eyes.

(The SRK T formula has made the SRK 2 formula obsolete since it combines all the advantages of the SRK 2 formula and also enables you to optimize the A-Constant)

The Hoffer-Q formula*: *Third generation formula

• Was described by Dr. Kenneth Hoffer in 1993.

• P = f (A, K, Rx, pACD)

• K(K reading)-average corneal refractive power (K-reading)

• A-Axial length

• Rx-refraction

• pACD personalized ACD (ACD-constant)

pACD – the personalized A constant was the equivalent of the A-Constant in the SRK formula. It was extremely reliable in short eye balls with an axial length of less than 22.0mms.[16]

THE FOURTH GENERATION FORMULA

Haigis

Holloday 2

HAIGIS Formula:

(1) DL = L - d n/z - d

• D - refractive power of IOL

• L - axial length

• d - optical ACD

• n : refractive index of aqueous and vitreous (1.336)

Haigis formula is a 4th generation formula which was an adaptation of the formula first suggested by Gernet, Ostholt and Werner as early as 1970. The versatility of the formula lies in the three individualized A constants namely a0, a1 and a2. The a0 is linked to the manufacturers lens constant. The a1 is linked to the pre operative ultrasonically measured ant chamber depth (this has a default value of 0.4) and a2 which is linked to the axial length measurements and which has a default value of 0.1.[17]

The three 'A constants' enable us to customize each component of the IOL formula. When fully optimized this formula will work across the entire range of axial length values and you may not need to use different formulae for different axial lengths.

Holladay 2: 4th Generation Formula

The Holladay 2 (1998) - 4th generation formula is currently the most sophisticated formula that you could possible lay your hands upon. It is an improvement on the Holladay 1 formula. The unprecedented success of the formula lies in the fact that Dr Jack T Holladay has attempted to increase its accuracy and predictability by incorporating seven different parameters into the framework of the formula. These parameters contribute towards the accurate estimation of the ELPo.[18]

- Axial length.
- Central power of the cornea (K)
- Anterior chamber depth
- Lens thickness measurement
- white to white measurement
- Age of the patient
- Previous refraction of the patient.

The second reason for the success of this formula is the development of the ‘nine types’ of eyes model by Dr. Holladay.

This model overcame the discrepancies in all the other IOL formulae, which revolved around the assumption that there was a constant relationship between the central corneal power (K), the pre operative anterior chamber depth and the axial length measurement. For instance in eye ball with long axial lengths the formulae automatically assumed that the anterior chamber depth would also be longer and vice versa and similarly in a steeper cornea the formula presume a greater anterior chamber depth and vice-versa.

METHODS OF IOL POWER CALCULATION

A-SCAN:

A-scan ultrasonography is the conventional method for measurement of axial length of the eye ball.

- Applanation technique

-Immersion ultrasound technique

APPLANATION TECHNIQUE:

In applanation technique , the probe is placed directly on the cornea, which slightly indents the surface of the globe[19].

- Gives falsely short axial length
- Corneal micro-abrasions may occur
- Variable corneal compression
- Highly operator dependent

IMMERSION TECHNIQUE:

The immersion technique is done by using a coupling fluid between the cornea and probe. The ultrasound probe does not come into direct contact with the cornea and there by preventing indentation of cornea[20].

- Consistent alignment when used with the Prager shell.
- No corneal contact and compression
- Less operator dependent
- More accurate

The ultrasonic biometer measures the transit time of the ultrasound pulse and, using estimated ultrasound velocities through the various media and calculates the distance, true echo spikes are visualized in the oscilloscope.

IOL MASTER

IOL MASTER:

It is a non-contact optical device which measures the distance between the corneal vertex and the retinal pigment epithelium by partial coherence interferometry.[21]

PRINCIPLE:

IOL Master employs the principle of Optical coherence Biometry(OCB) based on the Michelson interferometer .The laser diode generates infrared light of short coherence length which is reflected into the eye by mirrors, after being split into two equal coaxial beams by the beam splitter .

One mirror of interferometer is fixed and other is moved at constant speed making one beam out of phase with other. Both beams are projected in the eye and get reflected at cornea and retina. The light reflected from the cornea interferes with that light reflected by the retina if the optical paths of both beams are equal. This interference produces light and dark band patterns which is detected by a photo detector.

The signals are amplified, filtered and recorded as a function of the position of the mirror. An optical encoder is used to convert the measurements into axial length measurements .

Special feature incorporated is use of dual beams. In interferometer eye needs to be absolutely stable so as not to disturb interference patterns. Use of dual beams makes IOL Master insensitive to longitudinal movements and measurements can be made with ease.[21]

IOL MASTER Vs A SCAN

Commonly used ultrasound A scan uses 10 MHz probe which has a accuracy of 0.1 mm . Applanation scan touches the the cornea which causes indentation of the globe and gives falsely short axial length. Immersion A scan, though more reliable is time consuming and also uncomfortable to patient.[22]

IOL master measures the axial length from corneal apex to retinal pigmentary epithelium, while A scan measurers up to vitro retinal interface only. Thus IOL Master gives the true refractive length than anatomical axial length. IOL Master is non contact, ultra high resolution biometry. It is user friendly.

Ametropic patient can wear glasses while sitting on IOL Master which aids in fixation. This has advantage in measuring fovea in cases of posterior staphyloma. However significant media opacities limit the use of IOL Master.

KERATOMETRY

As a combined biometry instrument IOL Master measures other aspects also. Central corneal power is measured as in automated keratometry. Patient asked to focus straight and blink several times to get an even tear film.

WHITE TO WHITE MEASUREMENT

IOL Master can give easy measurements of WTW distance.

Focus should be on the iris rather than cornea. Measuring WTW distance is useful in calculation of phakic IOL

IOL POWER CALCULATION:\

After taking axial length and keratometry readings, IOL power mode is activated. The values of mean axial length and keratometry are passed on automatically. It then calculates IOL power for the different types of lenses. Results for four different types of lenses are displayed at a time . Up to 20 surgeons name and correspondingly data of their preferred lenses can be entered.

IOL powers are displayed in the steps of 0.5 diopters or 0.25 diopters. five popular IOL power calculation formulae are Holladay, haigis, SRK II, SRK T and Hoffer Q are included in the software While calculating IOL power surgeon can choose his preferred formula. Recent version of the machine has mode for phakic IOL and post refractive surgery patients.

The manufacturer estimates the A constant by approximating from similar lens models. The final lens position in capsular bag will be influenced by IOL style and surgical technique (rhexis, incision, phaco technique). Therefore

A constant provided by manufacturer needs to be optimised as per surgeon's technique.

LIMITATIONS

The IOL Master fails to measure in cases of mature, hypermature cataract, in unsteady eyes with nystagmus ,dense posterior capsular opacity.[23]

MODALITIES OF CATARACT SURGERY

Phacoemulsification

The goal of Phacoemulsification is to remove the cataract through a small incision using ultrasonic power produced by piezoelectric cystal that converts electrical energy into mechanical vibration in the phacohandpiece[11].

Conventional Extracapsular Cataract Extraction (ECCE):

Extracapsular cataract extraction is a group of techniques of preserving the posterior capsule which supports for placement of posterior chamber intraocular lens . A large incision (10-12mm) is made in the cornea or sclera. At the end of the surgery wound is closed and stabilised by sutures.the conventional method may be indicated for patients with very hard cataract or other situation in which phacoemulsification is problematic[12]

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PHACOEMULSIFICATION

ALCON INFINITY PHACOEMULSIFICATION MACHINE

PHACODYNAMICS

INSTRUMENTATION:

A thorough understanding of the phacoemulsification is imperative for Every phaco surgeon.each machine has different design feature. however, the basic functions of all machines remain the same. It is critical that every surgeon learns about the machine parameters and their individual effects, how they interrelate and in total how they determine the surgical environment in which the surgery is performed.

BASIC FEATURES

Every phacomachine has three basic functions.these are

1. Irrigation,
2 Aspiration
3 .Ultrationic fragmentation

Correspondingly two hand pieces are used in phacoemulsification,

1. The irrigation aspiration hand piece and
2. Phaco or ultrasonic handpiece

IRRIGATION ASPIRATION HANDPIECE:

The irrigation aspiration hand piece has a silicone sleeve that fits snugly around the aspiration tip. Through this sleeve irrigation is delivered.The I-A tip differs from the phaco tip in being smooth and rounded with a single aspiration port on the side of the tip and not at the end.The sleeve may be turned to orient the irrigation port in any direction. The irrigation ports in the silicone sleeve should be kept perpendicular to the metallic aspiration port as this helps to direct the infusion fluid along the iris plane. This reduces iris flutter during the surgery .

A variety of I-A tips are available: straight,45 or 90 angulation:

0.2mm,0.3mm and 0.7mm lumen diameters. most frequently used is the 0.3mm tip. during use for irrigation, the foot pedal is on position 2.

ULTRASONIC HANDPIECE:

Phacoemulsification surgery is based on ultrasonic power which is the function of the acoustic vibrator is a hollow titanium needle or the phacotip. the acoustic vibrator oscillates longitudinally at a frequency between 30,000-60,000Hz. This imparts a linear motion to the ultrasonic tip. The Stroke amplitude of the linear movement is 3/100 of an inch and the acceleration 80,000-2,40,000G.

PHACO TIP

The energy so produced along the ultrasonic handpiece is then transmitted onto the phaco tip. The phaco tip is made of titanium and is hollow with the distal opening functioning as the aspiration port. The phacotip can have various bevel angles ranging from 0-60 most commonly used are 30 and 45 phacotips.

ASPIRATION PUMPS

Depending on the machine, three kinds of pumps are used to control aspiration and produce the negative suction pressure i.e vaccum. they are

PERISTALTIC PUMP(Constant flow)

Peristaltic pump was popularized by heart lung machine.in these pumps a pressure differential is created by compression of the aspiration tubing in a rotator motion.when the rotational speed is low,vaccum develops only when the aspiration port is occluded. on occlusion, vaccum builds up to preset value in a step ladder pattern.by increasingly the rotational speed, as in the newer generation machines, A linear build of vacuum occurs ever without occlusion of the tip.It can thus be made to stimulate a venture or a diaphragmatic pump.

VENTURI PUMP(CONSTANT VACCUM)

Venturi pump uses compressed gas to create inverse pressure. Vaccum generated is related to gas flow which in turn is regulated by a valve. vaccum build up occurs linearly in a consistent manner from zero to preset value. the build up is almost instantaneous on pressing the foot pedal,due to this there is an increased risk of iris trauma and posterior capsular rents.which makes these pumps unsafe, particularly for beginners.

DIAPHRAGMATIC PUMP(CONSTANT PUMP)

Diaphragmatic pump uses a flexible membrane within a cassette to generate vaccum.Build up of vaccum is more linear and reaches the preset level even without occlusion .this makes it unsafe,lens materials can be aspirated without having to mechanically approach it.

FOOT PEDAL

The model of operation in which the instrument is functioning on depressing the foot pedal in a linear manner is shown by the position indicator.

POSITION 1: Only irrigation solution is flowing.

POSITION 2: Irrigation and aspiration occur simultaneously

POSITION 3: Irrigation, aspiration and fragmentation take place Simultaneously

MECHANISM OF ACTION OF PHACO

Factors involved include:

- A mechanical impact of the tip against the lens.
- An acoustic wave transmitted through fluid in front of the tip
    - c. Cavitation: At the cessation of the forward stroke,the tips has
        - Imparted forwart momentum to the fluid and the lens particles in
        - front of it on the tip.the void is collapsed by the
        - implotion(cavitation) of the tip therby creating additional shock
        - waves

d. There is an impact of fluid and lens particles being forward in front of the tip

PHACO PARAMETERS

- Ultrasound power

  The ultrasound power is usually about 50% to 70%.If the lens is soft, it is decreased to about 30% and if it is hard, power is increased to 80% to 90%.

- Effective phaco time

  It is the total time at 100% phacopower. effective phaco time is very significant as less effective phaco time that indicated proportionately less energy delivered to the eye there by reducing the side effects of phaco power.

- Phaco power

  It is the ability of the phaco hand piece to cut or emulsify cataract. phacopower is directly related to stroke length and efficiency of hand piece.

- Stroke length

  Stroke length is the distance by which the titanium phaco tip moves to and fro. It is most important factor in deciding the phacopower.the stroke length can be altered by changing the phacopower setting of the machine.

- Frequency

  Frequency is the number of times the tip moves and it is fixed for a Particular phacohandpiece. It is measured in KHz's. power variables are adjusted intraoperatively depending on:

  - Density of nucleus where phaco tip engaged
  - Amount of tip engaged.
  - Linear velocity of the tip during emulsification.

While too little a power will fail to cut the nucleus ,too much power will cause the nucleus to fly away from the ultrasound tip.

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PHACOEMULSIFICATION SURGICAL PROCEDURE

PHACOEMULSIFICATION

A single instrument technique for cataract extraction using ultrasound vibration to remove lens material through a 3mm corneal incision first described by kelman in 1967.[24]

OPERATIVE STEPS

INCISIONS AND WOUND CONSTRUCTION

phacoemulsification has become the procedure of choice for cataract surgery. The temporal approach is specifically suited for a clear corneal incision.

Types of corneal incision

- Triplanar
- Biplanar
- Uniplanar

2.CONTINUOUS CIRCULAR CAPSULORHEXIS

A capsulorrhexis can be created Using a bent 26 G needle.The idea is to initiate a tear in the central part of the anterior capsule,then lift the capsular flap,then the flap can be turned around the central axis in a circular manner, when completing the capsulorhexis one should overlap the tear in such a manner that the last part of the tear joins the first part from the outside towards the centre,thus resulting in a continuous edge.thus a central circular opening is created in the anterior capsule which provides access to the underlying cataract[27.]

3.HYDROPROCEDURES

Balanced salt solution is used as a physical,cleaving force constitutes hydroprocedures, hydrodissection and hydrodilineation[25]

HYDRODISSECTION:

The infusion fluid is injected exactly between the anterior capsule and the cortex, so that the fluid wave is spreaded all around the capsular bag and separates the nucleus from the underlying capsule.this facilitates nucleus rotation and manipulation during phacoemulsification.

HYDRODELINEATION:

Hydrodelineation is performed by injecting the fluid between the epinucleus and nucleus.The posterior epinucleus created by hydrodelineation acts as a cushion safeguarding to a certain extent the posterior capsule during phacoemulsification.

4.PHACOEMULSIFICATION BY DIVIDE AND CONQUER:

Divide and conquer is the most commonly practiced technique for emulsification .this technique reduces the phaco power and time thus making the procedure.[26]

Surgery is initiated by moderate amount of sculpting with some trench digging. In this technique,two deep grooves or trenches are made in the nucleus,extending to about 80 to 90 percent depth.these are right angles to each other .the nucleus is then divided into four segments, and each segment is then emulsified separately

STOP AND CHOP:

This involves trenching,splitting the nucleus in two halves,chopping,and phacoaspiration.

TRENCHING

Initial trench is made at low vaccum setting and power setting is done depending on hardness of nucleus.Two deep trenches are made in the nucleus, upto 80 -90 percent depth.the nucleus is divide into four segments along these grooves, and each segment is emulsified.

SPLITTING

Splitting is done using two instruments, using phaco probe and a chopper or two choppers held deep into the trench and force applied in opposite direction to crack the nucleus into two hemispheres

CHOPPING

During chopping nucleus is split into small pieces, the phaco probe is Buried into the hard body of the nucleus And a vaccum hold is achieved once good hold is achieved,second instrument chopper is used to crack the nucleus.Each hemisphere is divided into 3 pieces and these smaller pieces are emulsified

DIRECT CHOP

In this technique , no trench is made and probe is buried in the center of the nucleus and fragments are generated by chopping.

Basically there are two technique of chopping,

Peripheral

Central

CORTEX REMOVAL

The parameters on the phaco machine has to be changed from the phaco mode to the irrigation-aspiration mode.these are separately caliberated for the phaco probe and the irrigation-aspiration tip because of different orifice sizes.

Irrigation-aspiration tip is smaller than the phaco tip,thus higher flow settings can be safely used.the aspiration tip is positioned below the rhexis margin and in the cortical fibres,once the cortex has been firmly grasped,it is pulled to the centre and aspirated.

IOL IMPLANTATION

Foldable IOL's are injected into the bag by an injector system.

Advantage of injecting system

- Can Insert through a Smaller incision
- Cartridge are disposable

CLOSING THE PHACO INCISION:

The viscoelastic is removed from the chamber and in turn inflated with irrigating fluid. The integrity of the incision should be check by depressing the posterior lip of the incision.If the incision is leaking, hydration of corneal stroma may be tried at the extreme end of the incision. The corneal oedema pulls the tissue against each other and helps in a leak proof closure.

AIM

To compare the accuracy of five IOL power calculation formulas as calculated by the IOL master and to determine the efficacy of the predictive error by comparing this with the post-operative refraction.

OBJECTIVES:

- To compare the accuracy of five IOL power calculation formulas by comparing prediction errors as calculated by the IOL master.
- To compare the actual and predicted post-operative refractive error among groups of different axial length.

MATERIALS AND METHODOLOGY

Study area:

Cataract clinic and services, Aravind Eye Hospital, Madurai.

Study subjects:

100 eyes of 100 patients who have been advised phacoemulsification with intraocular acrylic lens implantation were included.

Study period:

January 2011 to July 2012

Sample size:

100 eyes

INCLUSION CRITERIA

- Visually significant cataract
- Suitable for phacoemulsification
- Primary implantation of posterior chamber intraocular lens
- Willing for participation in study

EXCLUSION CRITERIA

- Eyes with co-existing pathology
- Combined cataract surgery
- Previous intraocular or corneal surgery
- Corneal astigmatism greater than 1.5 D
- Eyes in which axial length could not be determined by IOL master
- Traumatic cataract
- Uveitic cataract
- Paediatric cataract
- Corneal Opacity

- Intraoperative complications
- Other ocular pathology causing visual impairment that was revealed after surgery.
- Patients who did not come for the one month follow-up

METHODOLOGY

Patients with significant cataract requiring surgery who satisfied the inclusion criteria as mentioned above were selected. 100 eyes of hundred patients who were advised phacoemulsification with acrylic IOL were included.

The complete examination of patients was done preoperatively. This included visual assessment by snellen's chart, refraction, complete anterior segment examination, grading of cataract using slit-lamp biomicroscopy and fundus evaluation was done.

Axial length, keratometric power, anterior chamber depth were measured using the IOL Master. IOL power was generated using the following five formulas: Hoffers Q, SRK II, SRK T, Holladay I and Haegis.

The patients were screened for diabetes mellitus, hypertention and history of any other systemic illness was obtained. They were then counselled for cataract surgery and consent was obtained in the consent form.

Anesthesia was given either topically or injected in the retrobulbar space. Phacoemulsification was performed by a single competent surgeon. In all cases, Acrysof IOL (a hydrophobic acrylic IOL) was implanted in the bag. All surgeries were uneventful. There were no intra-operative complications.

The intraocular lens to be implanted was decided depending on the axial length. In patients with an axial length less than 22 mm, the IOL power as calculated by the HOFFER Q formula was implanted. In patients with an axial length between 22 and 24 mm, the IOL power as calculated by the SRK II formula was implanted. In patients with an axial length of more than 24 mm, the IOL power as calculated by the HOLLADAY I formula was implanted.

Axial length	**Formula implemented**
<22 mm	HOFFER Q
22 – 24 mm	SRK II
>24mm	HOLLADAY I

All patients were given a post-operative course of topical antibiotic and steroid eye drops to be tapered over a period of six weeks. Patients were told to review after one month.

On the follow-up visit at one month, vision was determined using Snellen's chart and a dynamic retinosopy and refraction were performed. Slit-lamp evaluation of the anterior segment and fundus was done.

The one month post-operative refraction was compared with the predicted post-operative error determined by the IOL master for the different groups.

The mean absolute error (MAE) was defined as the average absolute error which was the actual postoperative spherical equivalence (SE) minus predicted postoperative refractive error. Comparison of the MAE in the three groups of axial length was done.

RESULTS

The predictive error calculated for five IOL power calculation formulae (SRK II, Hoffer Q, SRK T, HOLLADAY I and Haigis) as generated by the IOL master was compared.

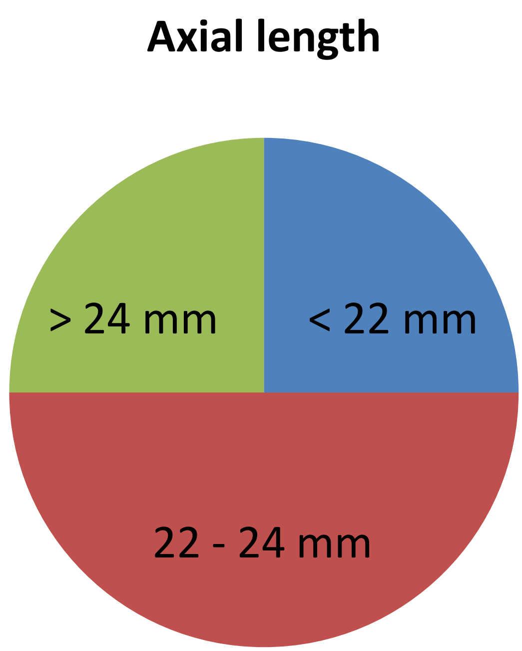
The accuracy of the predictive error calculated by the IOL master was determined by comparing this with the one month post-operative refraction for three different groups divided based upon the axial length as <22 mm, 22- 24 mm and >24 mm.

Statistical methods

Continuous variable are expressed as Mean(SD) and Categorical variables are expressed as ‘frequency(percentage)’. Repeated measure analysis of variance was used to assess the difference between IOL calculation formulae. P-value<0.05 considered as statistically significant. Statistical analysis was done by STATA software version 11.0.

1. DEMOGRAPHIC DATA

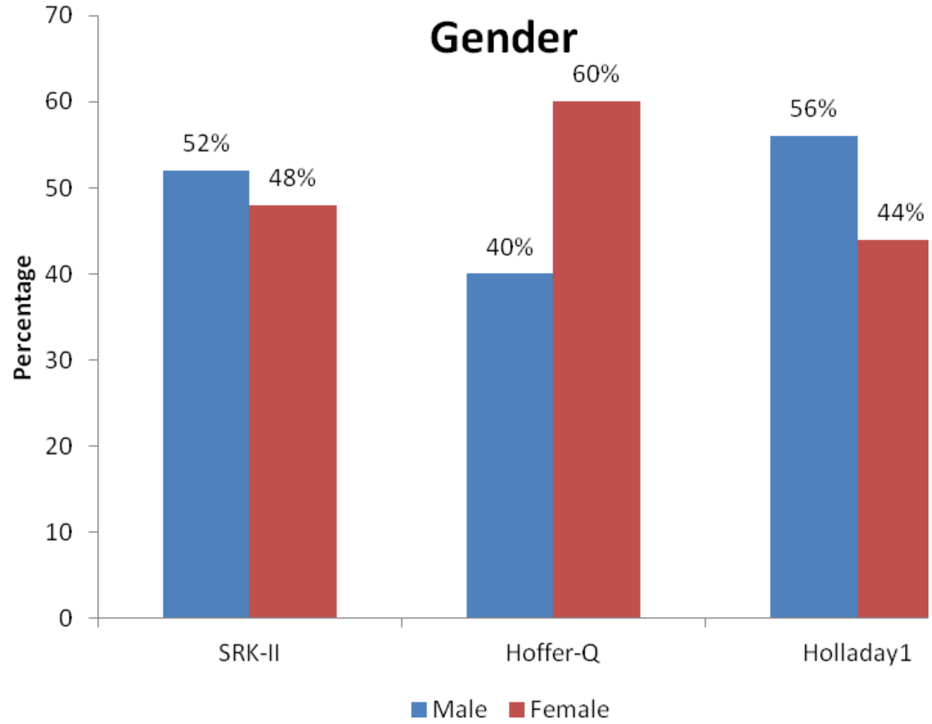
Of the 100 patients, 50 subjects fell in the category of axial length between 22 – 24 mm. Twenty five subjects each were included in the axial length groups of < 22 mm and >24 mm.



2. GENDER DISTRIBUTION:

The gender distribution among the three groups was as described in the table below.

GENDER	**IOL power calculation Formula**			**Total**
	SRK-II (Axial length 22-24 mm)	**Hoffer-Q** (Axl length < 22 mm)	**Holladay1** (Axl length > 24mm)	
Male	26(52.0)	10(40.0)	14(56.0)	50
Female	24(48.0)	15(60.0)	11(44.0)	50
Total	50	25	25	


Gender
Percentage
70
60
50
40
30
20
10
0
52%
48%
40%
60%
56%
44%
SRK-II
Hoffer-Q
Holladay1
Male
Female

COMPARISION OF ACTUAL AND PREDICTED POST OPERATIVE REFRACTIVE ERROR

The predicted post-operative error generated by the IOL master has been compared with the actual refractive error one month post-operatively within each group.

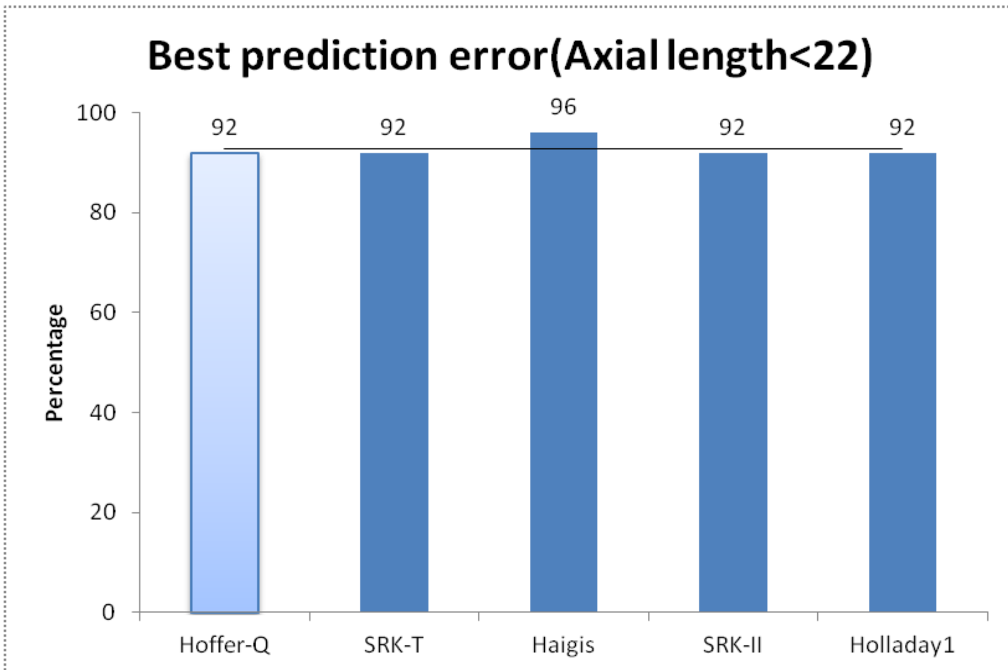
Formula	Predicted values	Observed values	P-value
SRK-II	-0.013(0.125)	0.012(0.300)	0.559
Hoffer-Q	-0.004(0.114)	-0.023(0.303)	0.780
Holladay1	-0.004(0.112)	0.026(0.264)	0.568

There was no statistically significant difference between the predicted values and the observed values.

BEST PREDICTION RESULTS (+-0.5 DS CORRECTION)

IN < 22 mm GROUP

Formulae	**Total**	**n(%)**
Hoffer-Q	25	23(92.0)
SRK-T	25	23(92.0)
Haigis	25	24(96.0)
SRK-II	25	23(92.0)
Holladay1	25	23(92.0)



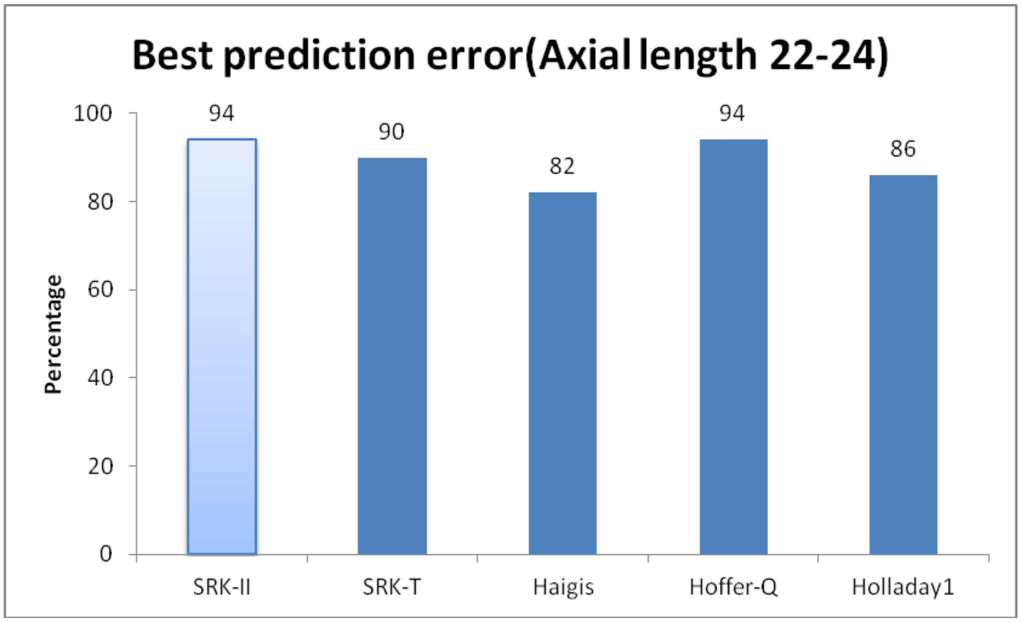
In <22 mm group of axial length ,HOFFERQ yielded best prediction results (+-0.5 DS) in 92% of patients,while HAIGIS formula yielded best prediction results in 96% of patients.

IN 22-24 mm GROUP

Best prediction (+/- 0.5 corrections)

In this group SRK-ll and HOFFER Q yielded best prediction results in 94% of eyes. Haigis yielded best prediction results in 82% of patients.

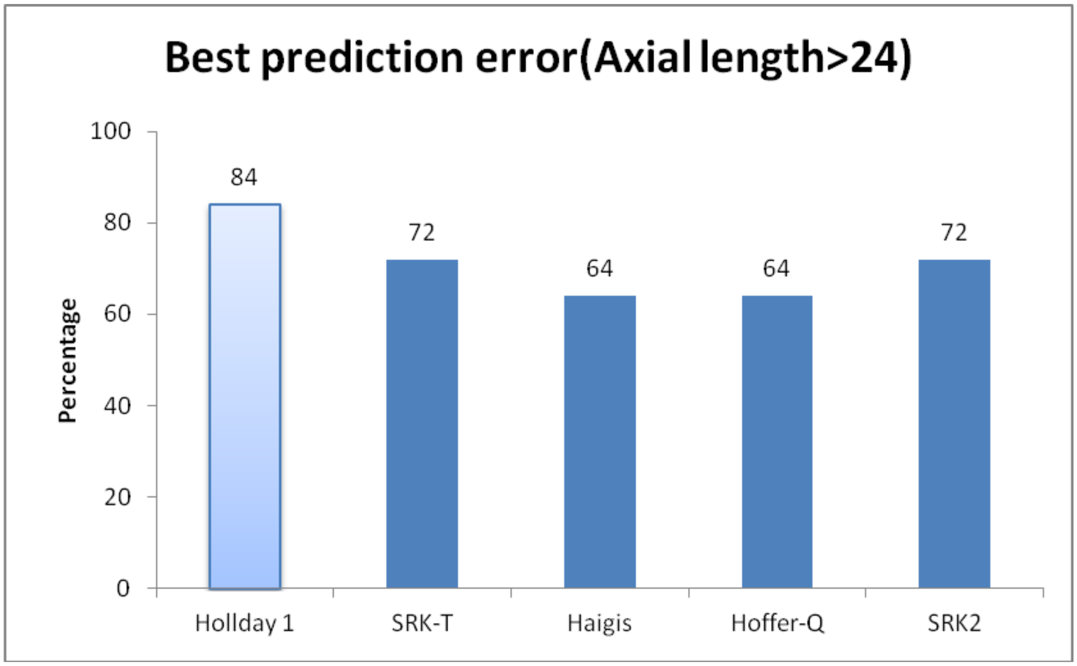
Formulae	**Total**	**n(%)**
SRK-II	50	47(94.0)
SRK-T	50	45(90.0)
Haigis	50	41(82.0)
Hoffer-Q	50	47(94.0)
Holladay1	50	43(86.0)



IN >24 mm AXIAL LENGTH

In >24mm Axial length group Holladay 1 yielded best prediction results in 84% of eyes.SRK-T and SRK II yielded best prediction results in 72% of patients.Haigis and Hoffer-Q yielded in 64% patients only.

Formulae	**Total**	**n(%)**
Hollday 1	25	21(84.0)
SRK-T	25	18(72.0)
Haigis	25	16(64.0)
Hoffer-Q	25	16(64.0)
SRK2	25	18(72.0)


Best prediction error(Axial length>24)
100
80
60
40
20
0
Percentage
84
72
64
64
72
Hollday 1
SRK-T
Haigis
Hoffer-Q
SRK2

COMPARISION OF ABSOLUTE PREDICTION ERRORS WITHIN THE DIFFERENT FORMULAE:

The absolute prediction error is determined by the difference between the actual error and the error predicted by the IOL master pre-operatively. The mean absolute error (MAE) was defined as the average of the absolute numeric error which was the actual postoperative spherical equivalence (SE) minus predicted postoperative refractive error. Comparison of the MAE in the three groups of axial length was done.

Mean absolute prediction error (Axial length <22.00mm)

Formula	**Mean(SD)**	**Min – Max**	**P-value**
Hoffer-Q	0.251(0.220)	0 – 0.95	0.440*
SRK-T	0.225(0.203)	0 – 0.86	
Haigis	0.207(0.163)	0.01 – 0.59	
SRK-II	0.224(0.177)	0.05 – 0.75	
Holladay1	0.224(0.179)	0.03 – 0.67	

*Repeated measure analysis of variance

Mean absolute prediction error (Axial length 22.00mm to 24.00mm)

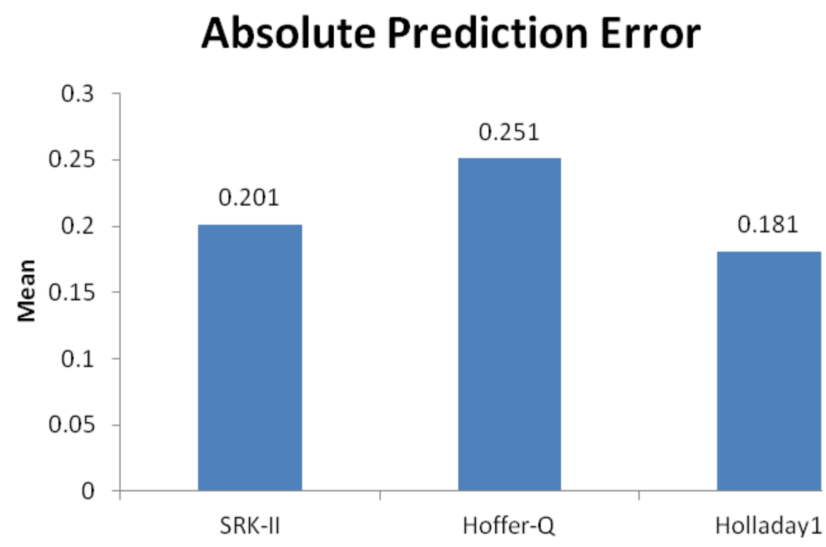
Formula	Mean(SD)	Min – Max	P-value
SRK-II	0.201(0.208)	0 – 1.15	0.769*
SRK-T	0.198(0.209)	0 – 1.22	
Haigis	0.196(0.216)	0.01 – 1.13	
Hoffer-Q	0.198(0.210)	0 – 1.15	
Holladay1	0.213(0.230)	0 – 1.16	

*Repeated measure analysis of variance

Mean absolute prediction error (Axial length >24.00mm)

Formula	Mean(SD)	Min – Max	P-value
Hollday 1	0.181(0.168)	0.03 – 0.77	0.353*
SRK-T	0.192(0.196)	0.03 – 0.67	
Haigis	0.194(0.209)	0.02 – 0.72	
Hoffer-Q	0.238(0.260)	0 – 0.85	
SRK2	0.195(0.210)	0 – 0.72	

*Repeated measure analysis of variance



There was no statistically significant difference in the predictive accuracy of the three formulae in the prediction of post-operative spherical equivalent measured by the mean absolute error.

DISCUSSION

The first IOL power calculation formula was published by Fydorov and kolonko in 1967.In 1978, Lloyd and gills, Rezlaff, Sanders and Kraff developed a regression formula based on the analysis of their previous IOL cases.In 1981, Binkhorst presented his modified formula which had better predictability than the first generation. Third-generation formulas (Holladay 1, SRK/T, and Hoffer Q) improved the predictor of effective lens position . Fourth-generation formulas such as the Holladay 2 is a refraction formula which requires corneal power, preoperative refractive error,and desires post operative refraction.

Of the available diagnostic instruments, the IOLMaster measures AL with the highest precision. The IOLMaster provides all biometric parameters and various formulas for IOL power calculation.

In our prospective study constituting 100 eyes of south Indian population , the IOL power was calculated using IOL master, and a single surgeon performing small incision phacoemulsification surgery with implantation of hydrophobic acrylic foldable IOL(Acrysoft) and postoperative refraction was done at 1 month. These refractive outcomes in 100 eyes were statistically compared with the IOL power calculation formulas(Hoffer Q, SRK T, SRK II,Holladay1 and HAIGIS) in 3 subsets of axial length.

The intraocular lens to be implanted was decided depending on the axial length. In patients with an axial length less than 22 mm, the IOL power as calculated by the HOFFER Q formula was implanted. In patients with an axial length between 22 and 24 mm, the IOL power as calculated by the SRK II formula was implanted. In patients with an axial length of more than 24 mm, the IOL power as calculated by the HOLLADAY I formula was implanted.

In our study of 100 eyes the mean absolute error (MAE) (the average absolute error which was the actual postoperative spherical equivalence (SE) minus predicted postoperative refractive error) was calculated and compared for the five IOL calculation formulas(SRK II,SRK T,hoffer Q,HOLLADAY I and haigis) in the three groups of axial length ,which did not differ significantly from the other formulas(p value>0.05)

While in each group of axial length,best prediction results(within +/-0.5 correction) were compared.

LESS THAN 22 MM AXIAL LENGTH(SHORT EYES)

Young Rae , et al [10] evaluated the accuracy of intraocular lens power calculations for four different IOL power calculation formulas (SRK II,Haigis, Hoffer Q, and SRK/T) using IOL master in eyes with a short axial length (<22 mm)in 25 eyes,who underwent phacoemulsification with intraocular lens implantation.It was a retrospective comparative analysis , Preoperative Axial length and keratometric index measurement were calculated by the IOLMaster, and the predicted postoperative refractive error was Obtained using SRK II, Haigis, Hoffer Q, and SRK/T formulas. Two months after cataract surgery,postoperative refractive error was calculated using automatic keratometry.results were compared with the predicted postoperative error.

The mean absolute error was smallest with the Haigis formula, followed by those of SRK/T , SRK II, and Hoffer Q in 25 eyes with an AL shorter than 22.0 mm.They have inferred that the Haigis formula predicted the best refractive outcome in short eyes.

Gavin EA, et al compared the accuracy of the Hoffer Q and SRK-T formulae in eyes below 22 mm in axial length, in 41 patients, without a customised ACD constant. Biometry was performed using IOL master and IOL power was calculated using both SRK-T and Hoffer Q formulae . Refractive outcome was measured and the accuracy of the two formulae compared..Hoffer Q was found to be more accurate than the SRK-T formula in this series of eyes <22 mm axial length when customised ACD constants are not used[29]

While in our study for less than 22 mm(short eyes) group of axial length,(25 eyes), Haigis(96%) and Hoffer Q(92%) yielded best prediction results(within +/-0.5 correction) in short eyes.

There is no statistically significant difference between the formulas as measured by mean absolute error.

22 -24 MM GROUP OF AXIAL LENGTH(NORMAL EYES)

Julio Narvaez,MD,Grenith Zimmerman,Daniel H.chang,MD et al[7] compared the accuracy of intraocular lens power calculations using 4 IOL power calculation formulas HofferQ,Holladay1,Holladay 2, and SRK-T.

Study was a retrospective comparitive analysis in 643 eyes using immersion ultrasound biometry,manual keratometry reading, and postoperative observed spherical equivalent were obtained in 643 eyes of consecutive patients who had uneventfull cataract surgery with IOL implantation by same surgeon. The predicted post operative results were compared to the post operative spherical equivalent. optimized lens constant was used for each formula.. And they have found out that there was no significant difference between the formulas as measured by mean absolute error.

In our study for 22-24 mm group of axial length(50 eyes),SRK II and hoffer Q yielded best prediction results(within +/-0.5 correction) in 94% of cases(eyes)

There is no statistically significant difference between the formulas as measured by mean absolute error.

MORE THAN 24 MM GROUP OF AXIAL LENGTH (LONG EYES)

Collete S.L.Tsang et al[8] compared the accuracy of intraocular lens power calculation formulas in chinese eyes with high axial length ,retrospective study.

They have analysed 125 patients who had axial length longer than 25.0mm .the predicted postoperative refractive error was calculated by 4 IOL power calculation formulas, hoffer Q,SRK II,SRK-T, and Holladay 1. The absolute error was calculated by comparing the difference between the actual and predicted postoperative refractive errors and the accuracy of each formula were analysed. Of the four formulas, the Hoffer Q formula predicted the best refractive outcome in long eyes.[28]

Ghanem AA et al. studied the accuracy of different intraocular lens power calculation formulas in predicting a target postoperative refraction ± 1.0D (Diopters) in patients with long eyes (axial length ≥ 26.0 mm) in 127 eyes undergoing phacoemulsification axial length measurement using immersion ultrasound A-scan technique, and autokeratometry with or without computerized corneal topography for K readings were done. The IOL power was calculated using four formulas SRK-T, Hoffer-Q, Holladay-2, and Haigis formulas. Four months after surgery, refraction was done. Mean absolute error was compared for all formula Haigis formula showed the least deviation while SRK-T and other formulas showed a greater tendency toward hyperopia. Haigis formula is the best formula when minus power IOL is implanted.[30]

Sanders DR,retzlaff JA et al[28] compared the predictive accuracy of the SRK/T formula to the SRK II, Binkhorst II, Hoffer, and Holladay formulas in seven series of cases .In short eyes (less than 22 mm), all formulas performed well, with the SRK/T, SRK II, and Holladay formulas performing marginally better. In moderately long eyes (greater than 24.5 mm, less than or equal to 27 mm) the SRK/T and Holladay were again marginally better. In the very long eyes (greater than 27 mm and less than or equal to 28.4 mm), all formulas performed well.

While in our prospective study for more than (long eyes)24 mm group of axial length,(25 eyes)holladay I yielded best prediction results(+/-0.5 correction) in 84 % of patients followed by SRK T

As measured by mean absolute error,there was no significant difference in the IOL power prediction with the five commonly used modern formulas, Hoffer Q, SRK II, Holladay 1 ,SRK/T and HAIGIS formulas in 3 subgroups of axial lengths.

Major limitations of our study are relatively small sample size which limits the statistical comparision between the groups. Follow up of just 1 month is one other limitation.Also we would have used more than one formula in a particular group of axial length.

CONCLUSION

In this prospective study comparing different IOL power calculation formulas in attaining the best postoperative refraction ,we found that there was no statistically significant difference in the accuracy of intraocular lens power prediction with the IOL power calculation formulas Hoffer Q, SRK II, Holladay 1, SRK/T and HAIGIS under 3 subsets of axial lengths as measured by Mean Absolute Error.

Further randomized trial with large sample size is needed for comparison of the accuracy of intraocular lens power prediction using different IOL power calculation formulas.

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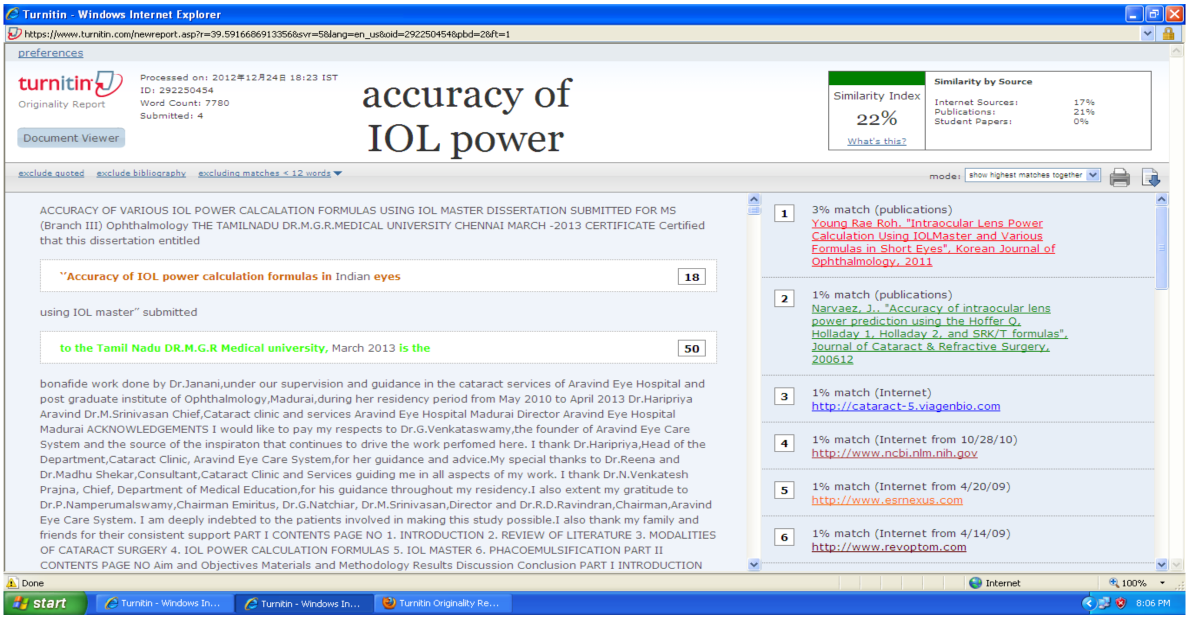
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ACCURACY OF VARIOUS IOL POWER CALCALATION FORMULAS USING IOL MASTER DISSERTATION SUBMITTED FOR MS (Branch III) Ophthalmology THE TAMILNADU DR.M.G.R.MEDICAL UNIVERSITY CHENNAI MARCH -2013 CERTIFICATE Certified that this dissertation entitled
"Accuracy of IOL power calculation formulas in Indian eyes
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using IOL master" submitted
to the Tamil Nadu DR.M.G.R Medical university, March 2013 is the
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bonafide work done by Dr.Janani,under our supervision and guidance in the cataract services of Aravind Eye Hospital and post graduate institute of Ophthalmology,Madurai,during her residency period from May 2010 to April 2013 Dr.Haripriya Aravind Dr.M.Srinivasan Chief,Cataract clinic and services Aravind Eye Hospital Madurai Director Aravind Eye Hospital Madurai ACKNOWLEDGEMENTS I would like to pay my respects to Dr.G.Venkataswamy,the founder of Aravind Eye Care System and the source of the inspiraton that continues to drive the work perfomed here. I thank Dr.Haripriya,Head of the Department,Cataract Clinic, Aravind Eye Care System,for her guidance and advice.My special thanks to Dr.Reena and Dr.Madhu Shekar,Consultant,Cataract Clinic and Services guiding me in all aspects of my work. I thank Dr.N.Venkatesh Prajna, Chief, Department of Medical Education,for his guidance throughout my residency.I also extent my gratitude to Dr.P.Namperumalswamy,Chairman Emiritus, Dr.G.Natchiar, Dr.M.Srinivasan,Director and Dr.R.D.Ravindran,Chairman,Aravind Eye Care System. I am deeply indebted to the patients involved in making this study possible.I also thank my family and friends for their consistent support PART I CONTENTS PAGE NO 1. INTRODUCTION 2. REVIEW OF LITERATURE 3. MODALITIES OF CATARACT SURGERY 4. IOL POWER CALCULATION FORMULAS 5. IOL MASTER 6. PHACOEMULSIFICATION PART II CONTENTS PAGE NO Aim and Objectives Materials and Methodology Results Discussion Conclusion PART I INTRODUCTION
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Young Rae Roh. "Intraocular Lens Power Calculation Using IOLMaster and Various Formulas in Short Eyes", Korean Journal of Ophthalmology, 2011
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Narvaez, J.. "Accuracy of intraocular lens power prediction using the Hoffer Q, Holladay 1, Holladay 2, and SRK/T formulas", Journal of Cataract & Refractive Surgery, 200612
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Holladay 1

S.NO	MR.No	Pre op findings			Actual refractive error (1 month post op)	Absolute error	SRK T	HAIGIS	HOFFER Q	SRK II		GENDER
		Axial length	Lens power	Residual refractive error								
1	3212002	24.07	20.5	0.04	0	0.04	-0.13	0.05	0	-0.2		M
2	3053532	24.25	18.5	-0.1	0	0.1	-0.06	-0.09	-0.1	0.1		M
3	2988317	24.44	19.5	0.15	0.37	0.22	0.03	0.1	-0.2	0.1		M
4	3093661	26.74	8	-0.12	-0.37	0.22	-0.02	0.16	`	0.2		F
5	3281000	24.04	17	0.11	0.05	0.06	-0.04	-0.03	-0.12	-0.11		F
6	3024603	28.82	4	-0.02	0.75	-0.77	0.08	0.15	-0.1	0.2		F
7	2991176	24.24	20	0.02	-0.05	-0.07	0.05	-0.13	0.1	0.02		F
8	3286271	24.14	19.5	-0.06	-0.25	0.2	-0.03	-0.14	-0.1	-0.2		M
9	2850104	24.11	19.5	-0.17	0.07	0.01	-0.13	0.017	-0.2	0.1		M
10	3286271	24.35	19.5	-0.14	0	-0.14	-0.1	0.05	-0.1	0.1		M
11	2989325	24.14	20.5	0.1	0.62	0.52	0.1	-0.1	-0.2	-0.1		M
12	3404401	25.24	12.5	-0.14	0	0.14	0.09	0.09	0	-0.1		F
13	3340699	24.15	20	0.04	0	0.04	-0.08	-0.06	0.1	-0.1		F
14	3022411	24.67	14	-0.11	0	0.11	-0.09	0.12	-0.11	0.2		F
15	3201059	25.97	11.5	-0.12	0	-0.12	0.05	0.2	-0.13	0.1		F
16	3053582	24.25	18	-0.11	0	0.11	-0.09	0.09	0.1	0.1		M
17	3090938	24.18	16.5	0.16	0	0.16	0.03	-0.14	-0.1	0		F
18	3206041	24.68	17.5	-0.16	-0.5	-0.34	0.13	-0.11	0	0.1		M
19	3283291	24.28	20	-0.08	0	0.08	-0.16	0.07	-0.1	-0.1		M
20	3289643	24.2	20	0.09	0	0.09	0.04	-0.02	0.13	0.09		M
21	3288673	25.01	15	0.13	0	0.13	-0.09	-0.12	0	0.1		M
22	3288673	24.81	15	0.1	0	0.1	0.09	-0.2	-0.1	0		M
23	3316884	24.5	16	0.08	-0.05	-0.13	-0.02	0.06	-0.2	-0.1		F
24	3339595	24.61	15	0.1	-0.05	-0.15	0.03	0	0.1	0.1		F
25	3299084	24.55	18.5	0.03	0	0.03	0.07	-0.16	0	0.1		M

SRK 2												
S.NO	MR.No	Pre op findings			Actual refractive error (1 month post op)	Absolute error	SRK-T	HAIGIS	HOFFERQ	holladay I		GENDER
		Axial length	Lens power	Residual refractive error								
1	3046431	22.93	21	-0.2	-0.375	0.175	0.02	-0.02	-0.1	-0.01		F
2	3055658	22.38	19	0.1	-0.375	0.475	-0.1	0.16	0	0.14		M
3	3202489	23.25	19.5	0.1	1.25	-1.15	0.03	0.12	0.1	0.09		M
4	3218435	23.02	21.5	0	0	0	-0.16	0.13	-0.1	-0.11		F
5	2941122	23.14	22	-0.1	0	-0.1	-0.16	0.08	0	-0.06		M
6	2877640	23.04	20.05	0	0	0	0.12	0.12	0	0.07		F
7	3115285	23.68	19.5	0.1	0	0.1	-0.02	0.13	-0.2	-0.07		F
8	3144419	22.48	20.5	0.2	0	0.2	0.1	0.2	-0.1	-0.12		F
9	2811449	23.01	22.5	-0.1	0	-0.1	-0.14	0.13	0.1	0.03		F
10	2817242	23.97	19	0	0	0	-0.17	-0.09	0	0.11		M
11	2994053	23.77	21	-0.1	0	-0.1	-0.05	0.05	0	0.06		M
12	2192786	22.7	20.5	-0.2	0	-0.2	0	-0.03	0.1	-0.15		M
13	3185559	23.29	21.5	-0.2	0	-0.2	0.01	0.17	0.1	0.05		M
14	3182857	22.47	20.5	0.1	0.375	-0.275	0.01	0.06	0.1	-0.13		M
15	3182973	23.12	21	-0.2	0.25	-0.45	-0.02	-0.09	-0.1	-0.02		M
16	2516689	23.37	19.5	0.1	0.375	-0.275	0.01	0.15	-0.1	-0.01		M
17	2911550	23.64	19	0.1	0	0.1	-0.05	0.12	0.1	-0.16		F
18	3110676	23.66	20.5	0	0.375	-0.375	0.13	0.08	-0.1	-0.15		F
19	3261523	22.4	22	0.2	0	0.2	-0.09	0.11	0	-0.03		F
20	3267784	23.23	20,50	0,2	0	0.2	-0.11	0.01	-0.1	-0.12		M
21	3256675	23.02	20	0.2	0	0.2	-0.12	0.03	0	0.12		M
22	3262041	22.2	23.5	0	0	0	0.13	-0.11	0	-0.16		M
23	3272357	23	19.5	0.1	0	0.1	0.14	0.01	-0.2	-0.03		M
24	3076108	23.34	19.5	-0.1	0	-0.1	0.17	-0.02	-0.1	0.02		M
25	3064122	23.38	19.5	-0.1	-0.5	0.4	-0.14	-0.03	-0.1	0.06		F
26	3241379	22.07	23	-0.2	-0.375	0.175	0.16	-0.1	0	-0.13		F
27	3280389	22.12	22.5	0.1	0	0.1	0.04	0.16	0.2	0.09		M

28	2851531	23.15	20.5	0.1	0.25	-0.15	0.16	-0.01	0.1	0.13		F
29	3244391	23.08	21	-0.1	-0.05	-0.1	0.09	-0.12	0.1	0.09		F
30	3244391	23.08	20.5	-0.1	-0.625	0.525	-0.04	0.2	0.04	0		F
31	3083055	22.84	19.5	-0.1	0	-0.1	-0.1	-0.05	0.2	0		M
32	3177249	23.21	21	0.08	0.375	-0.29	-0.13	-0.06	-0.07	-0.08		F
33	3322615	22.56	21	0.1	0	0.1	-0.16	-0.09	-0.01	-0.05		F
34	3254754	22.47	21	0	0	0	-0.04	0.1	0.1	-0.14		F
35	3251596	23.29	21.5	-0.1	0	-0.1	0.04	0.09	0.2	0.13		F
36	3118283	23.17	20.5	0	0	0	-0.16	0.02	-0.01	-0.02		F
37	3033685	23.13	20.5	-0.2	-0.375	0.175	0.07	-0.1	0.1	-0.15		F
38	3128254	22.85	21	0.1	-0.25	0.35	-0.06	-0.1	-0.1	-0.09		F
39	3282515	22.44	23	0	0.75	-0.75	0.15	-0.06	0.1	-0.05		M
40	3285995	22.1	22	0.1	0	0.1	-0.07	-0.05	-0.1	-0.08		M
41	3290982	22.95	21	-0.2	0	-0.2	0.02	0.04	-0.1	-0.07		M
42	2519845	23	19.5	-0.2	-0.25	-0.05	0.11	-0.06	-0.1	-0.07		F
43	3045070	23.18	19.5	0	0	0	0.02	0.11	0.1	-0.13		F
44	3240292	22.15	21.5	0	0	0	0.11	-0.04	0	0.03		M
45	3296328	22.56	19.5	0.1	0	0.1	-0.1	0.09	0.2	-0.02		M
46	3273391	22.73	20	-0.1	0	-0.1	0.03	-0.09	0	-0.15		F
47	3295341	22.54	21.5	0.1	-0.25	-0.35	0.09	-0.15	0.1	0.1		M
48	3295728	23.23	22	-0.11	0.25	0.36	0.13	0.06	0	-0.09		M
49	3318398	23.86	19.5	-0.2	0	-0.2	-0.14	-0.12	-0.1	0		M
50	3252126	23.46	20.5	0	-0.25	-0.25	-0.13	-0.02	0	0.08		M

Hoffer Q											
S.No	MR.No	Pre op findings			Actual refractive error (1 month post op)	Absolute error					
		Axial length	Lens power	Residual refractive error			SRK T	HAIGIS	SRK II	holladay I	GENDER
1	3133377	21.05	24	0.1	-0.375	0.475	0.05	-0.07	-0.1	0.06	F
2	3185710	21.88	22.5	0.1	-0.375	0.475	-0.12	0	-0.1	0.12	F
3	3262158	21.81	23	0	0.25	0.25	0.09	0.13	0.1	0.02	F
4	3275121	21.69	22	-0.1	0.05	-0.15	0.11	0.04	0.1	-0.11	M
5	3254814	21.85	23.5	0	-0.375	-0.375	-0.06	-0.06	-0.1	-0.1	M
6	3241567	21.74	24.5	-0.2	0	-0.2	0.08	-0.14	-0.1	0.1	M
7	3283842	21.87	23.5	-0.1	-0.5	0.4	-0.13	-0.12	-0.2	0.17	F
8	3285920	21.3	24.5	0.1	-0.5	0.6	0.09	-0.05	0	-0.05	M
9	3185993	21.63	24	0	0.2	0.2	0.164	0.15	0	-0.02	M
10	3368209	21.83	25	-0.1	0.25	-0.35	0.16	0.14	-0.1	0.11	F
11	3365321	21.87	21	0	0	0	0.13	-0.06	0.1	0.08	F
12	3334830	21.54	25.5	0	-0.375	-0.375	-0.1	0.05	0.1	-0.15	F
13	3396164	21.9	22	0	0.375	0.375	-0.06	0.03	-0.1	0.02	F
14	3394681	21.79	24	0	0	0	0.1	0.16	0.1	0.13	F
15	3197189	21.57	23	0	0.05	0.05	0.12	-0.15	0	-0.03	F
16	3340101	21.97	25	-0.2	-0.375	-0.175	0.06	-0.03	-0.2	-0.2	M
17	3328885	21.8	19.5	0.2	0.375	0.175	0.12	0.05	0.2	0.11	F
18	3255071	21.59	22	-0.2	0.75	0.95	-0.11	0.16	0	0.16	F
19	3319971	21.68	23	0.2	0	-0.2	-0.02	-0.04	0.1	0.1	M
20	3177805	21.56	24.5	-0.1	0	0.1	-0.1	-0.1	-0.2	0.09	F
21	2392984	21.9	23	0.1	0	-0.1	-0.14	0.03	0.1	0.03	M
22	2679677	21.87	22	-0.1	0.1	0.1	-0.13	-0.13	0.1	-0.1	M
23	3312005	21.74	21	0.1	0	-0.1	-0.14	-0.02	0.1	0.11	M
24	3185710	21.88	22	0.1	0	-0.1	0	0.1	-0.1	0.06	F
25	3256349	21.97	22.5	0	0	0	-0.16	0.05	-0.1	0.03	F